Globelics

Absorptive capacity of information and knowledge through Interfaces in the customized software industry: The case of micro and small-sized Mexican firms.

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Synthesis

This paper contributes the understanding of how *interface* allows to the producers identify specific information and knowledge from the users (and other agents), and how it influences on firm's *absorptive capacity*. We suppose that the great dynamism of the Information Technology Industry brings about uncertainty to the micro and small-sized Mexican software firms, and one way to reduce it is through the interfaces. This mechanism allows the software firms to know (identify) important parts of information and knowledge from the users, and if the firms have the ability to internalize them they could design and develop new software products. This causal effect will be present in the paper. The aim of this work is to explain how the Mexican software firms that produce customized software create different interfaces, and how they can increase their absorptive capacity starting suitable processes of internalization of information and knowledge that exist in the environment but also that generated in the interface. We suggest that the *external* interfaces are a crucial learning mechanism that influences the increase the firm's absorptive capacity. It will be illustrated by exploratory multiple-case study.

Key words: Absorptive Capacity, Interface, Knowledge, Software Firms.

Introduction

Information Technology (IT) industry is on a stage of great technological change, particularly software industry is very dynamic where software technologies (tools, applications or programs, and so on) and user necessities change and evolve in a very fast way. This dynamism creates uncertainty and implies creation of great amounts of information and knowledge (I&K) that software firms need to identify and absorb in order to design and develop software programs. It is important in the customized software industry.

In Mexico software industry is on a stage of development and growth. The industry has an atomistic structure: 87% are micro and small-sized firms, and most of them have an organizational structure of work based on a *multitask scheme*, which reduces the firm's capacity to create internal knowledge flows, especially for the micro and small-sized firms. The literature about absorptive capacity has studied in deep way medium and large-sized firms with formal and

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functional areas, for instance, the R&D unit. Starting this unit, the firms are able to identify and internalize I&K generated in the environment and, at the same time, are able to transfer them to the rest of the areas (Cohen and Levithal, 1990; Van den Bosch, *et al*, 1999 and 2002; Lane, *et al*, 2002; Lenox and King, 2003; Lund Vinding, 2004). But, what happen when the micro and small-sized firm do not have an organizational structure that allows them to build up internal knowledge flows? We suggest that external interfaces are crucial mechanism to build up external knowledge flows in order to identify useful I&K, these I&K are related to the requirements from the users. Andersen (1991 and 1996) suggests that an interface is a mechanism through which firms can interchange different kinds of information flows. The literature about interface refers to external information flows that are created through interfaces among producers and users, but it does not take into account how firms can internalize I&K.

Drawing on those bodies of literature, we suggest that one way to reduce technological uncertainty is through the interface, and this is the core mechanism to identify I&K and which influence on the firm's absorptive capacity.

The aim of this paper is to analyze how software firms create different interfaces, and how the firms can increase their absorptive capacity starting suitable processes of internalization of I&K that exist in the environment and that are generated in the interface. The central research question we will try to answer is about: How do Mexican software firms build up interfaces with other social actors? And, how do the interfaces influence on the firm's absorptive capacity in order to design and develop new products?

The research strategy is based on exploratory multiple-case study. The empirical analysis is sustained over interviews at project leaders and software developers in 6 firms, all of them design and develop customized software. The fieldwork was made between March 2004 and February 2006. The firms interviewed are located in four Mexican cities: Mexico D. F., Guadalajara, Leon and Monterrey.

This paper is organized in 4 sections. Section 1 presents the conceptual framework in which the concepts of interface and absorptive capacity are defined. Next section explains the research strategy followed in this research. Section 3 presents principal characteristics about the Mexican software industry. Next section presents and analyzes principal findings. Finally, we present conclusions.

I. Conceptual framework

Mechanism to increase the firm's absorptive capacity

Creating new knowledge implies different social processes such as learning activities. Literature about technological learning has showed that it could occur at individual and organizational levels. In this literature the organizational learning is crucial to accumulate technological capabilities. But at the same time, at the firm level, organizational learning is important to internalize information and knowledge through social processes, Vera-Cruz (2004) suggests that this learning is necessary in order to keep them into the firms, avoiding losing or forgetting them.

Firms need to absorb information and knowledge, this is suggested by Cohen and Levithal (1990), Van den Bosch, *et al* (1999, 2002), Lane, *et al* (2002), Lenox and King (2003), Lund

Vinding (2004), and some others. This implies that firms need to have the ability to evaluate, assimilate, and apply I&K to commercial ends; at the same time, these scholars suggest this capacity depends on mechanisms such as: prior related knowledge, training, learning activities, cross-function interface.
Prior related knowledge has important implications for the development of absorptive capacity over time. The reason is because "accumulating absorptive capacity in one period will permit its more efficient accumulation in the next…and to exploit any critical external knowledge that may become available" (Cohen and Levinthal, 1990:136). One of the most comprehensive and well-know contributions of accumulating absorptive capacity refers to accumulate internal capabilities. But, these scholars argue that internal capabilities and external collaborations are viewed as complementary. And an increased knowledge base will create more opportunities to exploit new technical developments by increasing the ability to internalize and exploit external knowledge (Lun Vinding, 2004:156).

Lane and Lubatkin (1998), and Lane, *et al*. (2002) suggest that the inter-organizational learning is an important mean to internalize external knowledge. One firm could learn from another, but to achieve it depends on the similarity of both firms in terms of knowledge bases, organizational structures and the establishment of systems for processing knowledge (Lane and Lubatkin, 1998:465). In other dimension, the inter-organizational learning is associated with an internal issue: with the intra-organizational learning. Van den Bosch *et al* (1999:551) suggests that the absorptive capacity depends on prior related knowledge (as Cohen and Levinthal, 1990, have suggested), but one of the most important arguments of these scholars is that absorptive capacity also depends on organizational structures and combinative capabilities, which are associated with a suitable system for processing knowledge (as Lane and Lubatkin, 1998, suggested). Van den Bosch *et al* (1999) suggest that different organizational forms directly impact on the absorptive capacity because each firm has different functional areas, and each functional design has specific efficiency, scope and flexibility. In this sense, each firm has different means to transfer knowledge, inter and intra functional areas, consequently communication structure could be different.

Jones and Crave (2001) analyzed how small-size firms increase their absorptive capacity, particularly through "the way managers mobilize their resources to identify, obtain and utilize [them into] new knowledge." The introduction of new organizational practices such as 'rotational roles into the firm' helped made a significant improvement for the absorptive capacity. This is particularly important in micro and small-size firms without a R&D[3] unit.

Cohen and Levinthal (1990) also argue to identify absorptive capacity it is necessary to examine structures of communication between 'the organizations and its environment as well as among subunits. In this respect, the premise about internal and external interfaces means to add new information and knowledge flows. Although the mechanism of interface has had less emphasis in the literature as a mechanism to increase the absorptive capacity, internal interfaces has been predominantly studied (interfaces among different firm's functional areas) upon external interfaces (interfaces among a firm and other social actors). Even though these authors do not define specifically an interface, but they do expand this concept to another circumstances.

[3] Research and Development, R&D, unit.

However, this literature is trying to interpret other realities, to say medium and big-size firms with functional areas, which usually includes an R&D unit; and this reality is not the same that show us the Mexican software industry context: micro and small sized-firms without explicit formal and functional areas, especially without an R&D area.[4] These firms do not have formal and functional areas, which inhibit the creation of internal functioning interfaces. Cohen and Levinthal (1990:135) argued that the discussion of the absorptive capacity's literature has been focalized on the internal mechanism that influence on the absorptive capacity, however, there are some firm specificities that can not be absorbed in an easy way or internalize them in a fast way, for instance, specific information and tacit knowledge from the users.

Drawing on this body of literature we suggest that *external interfaces* must be considered as a crucial mechanism to identify I&K from the users and other social actors; at the same time, the interface has an important role on the increase of firm's absorptive capacity. This causality is important in a dynamic technological environment (*i. e.* Information Technology Industry) where micro and small-sized firms predominate. These firms have an organizational structure of work based on a *multitask scheme*, which reduces the firm's capacity to create internal knowledge flows. Our multiple case study show that some Mexican software firms are able to internalize specific information and tacit knowledge available in the environment as well as that generated in the interface, but there are other firms that are unable to internalize them, it is to say, some of them have constraints to evaluate, assimilate and apply the information and knowledge to create new software products.

Next sections will show that the concept of interface implies different types of interaction among software firms and other social actors and not just different types of interaction among functional units into the firm.

Interface as a mechanism to identify information and knowledge

The concept of interface has been defined taking into account the concept of user-producer interaction defined by Lundvall (1985, 1988, and 1992). The user-producer interaction emphasizes on the relevance of interactive learning among the agents. The producers learn doing products (learning by doing) and the users learn using it (learning by using), the interaction among users and producers let them exchange their experiences (learning by interactive). The agents exchange technological information, knowledge and know-how about products, processes and organizational models. The interaction implies that learning by interactive lets to users and producers increase their innovation capacity and competitiveness. Lundvall (1988) suggests that user-producer interaction is based on different types of relations that depend on: i) symmetric and asymmetric relations among the agents, ii) standardization of the technology, frequency and duration of exchange, iii) economic and cultural context, iv) organizational dimension, and v) knowledge flows inside and outside the firm. This scholar studies the interactive process at microeconomic level and from it suggests a national innovation system.[5] Andersen (1991)

[4] In several papers R&D intensity has been used as a dependent variable and as a *proxy* of the absorptive capacity, however others scholars such as Lun Vinding (2004), Jones and Crave, (2001) and some others, include others factors such as an educational measure (for instance, doctorate workers), cumulative experience, organizational characteristics (for instance, internal structures).

[5] Lundvall (1985, 1988, and 1992) explains the microeconomic and institutional conditions, which are necessaries in a National Innovation System.

conceptualizes the user-producer interaction under a techno-economic paradigm at micro level,[6] and he calls interface to the user-producer interaction.

Andersen (1991:121) defines interface as "…a relationship between two agents in which there are different kinds of information flows. If an interface is simplified and standardized the information necessary for each one of the agents will be delimited…However, the innovation process presupposes an information-rich interaction and thereby non-standardized interfaces but complex interfaces."

The concept of interface implies technological stability among users and producers. This point has been developed by Andersen (1991) under two principles of interfaces designing. On the one hand, the principle of *commodity abstraction* minimizes the requirement of information flows, as a result we have simple and relatively stables interrelations necessary to the economic system. Given this principle is possible to create stabilized routines among the agents that are involved in the interface; if the routines are developed under the assumption of stable interfaces would have a few possibilities to modify the strategy as it is predictable users' requirements. This interface is associated with the maturity of the technology. One technology can be maturity and standardized, and the interface can be created and sustained for a long time. In this sense, it is possible to create a path of maintenance and evolution.

On the other hand, the second principle is *interactive learning* among producers and users, a sort of compulsory interaction to create new products, but at the same time this principle increases the requirement of information flows. Given this principle the interface can not be stable because of interactive learning implies strong links and effects that not belong to the economic exchange. This type of interface -compulsory interaction- is associated with the emergence of new technologies where interfaces tend to be different.

In a dynamic technological environment complex interfaces are important to develop new software products, processes, and services. On the one hand, for stable interfaces the users accept the standardized products that are in the market, even though the products are not appropriate for their requirements; so they assume principle of commodity abstraction. Other users benefit from products' incremental innovation, but they do not play an active role in the creation of these products. Finally, some users play an active role and create new products upgrading the complex interface; in this case, the principle of interactive learning is more important than commodity abstraction. The stability of the interface, in a dynamic technological environment, is associated particularly to the users' role in upgrading products. But there is another issue to consider: the mechanism which the firms obtain information and knowledge available in the environment, we must consider the mechanism which the firms internalize them. This point has not been suggested by the interfaces literature.

In this respect, drawing on this body of literature the concept of interface defined by Andersen (1991 and 1996) is very useful to understand the Mexican software industry reality. For this

[6] Perez (1986, 2002 and 2003), Freeman and Perez (1988) define Techno-Economic Paradigm at macro level, while Andersen (1991, 1996) defines it at micro level. The interplay among users and producers has a fundamental role in the definition of technological paradigm defined by Dosi (1982).

reason we will introduce this concept to the analysis of the absorptive capacity for a better understanding of the social interactive process.

II. Research Methodology

The research strategy is based on exploratory multiple-case study. The cases to be studied are micro and small-sized software firms that develop and design customized-software. The unit of analysis refers to the interface. The empirical analysis is sustained over interviews at project leaders and software developers in 6 software firms. The fieldwork was made between March 2004 and February 2006. The firms interviewed are located in four Mexican cities: Mexico D. F., Guadalajara, Leon and Monterrey.

The most important social interactions are: user-producer interaction, linkages between firm and university, and interaction between software firms and 'developer communities' of open-source software. This expands the concept of interface to other actors and highlights the kind of outputs.

Next table show us the approach at the concepts of interface, absorptive capacity and knowledge. For the first one we suggest five analytical categories: a) agents which the software firms interact, b) type of interaction, c) stability of the technology, d) intensity of the interaction, and e) formality or informality of the interaction. To approach the concept of absorptive capacity we suggest three analytical categories: a) prior related knowledge, b) I&K flows (internal flows), and c) learning activities.

Table 1.
Operationalization of the concepts

Concept	Variable (Approach to the concepts)	Indicator
Interface	Interaction with different agents	The agents are: enterprise, users, training centers, government agencies, and developer communities of open-source.
	Type and complexity of the interaction	The complexity of the interaction is identified through different software projects: a) Simple relations such as selling-purchasing contract. b) Adaptability of software that already exists in the firm c) Upgrading, designing and development new software, implantation, testing, maintenance, system integration d) Creation of new human resource, specialized training
	Stability of the technology	It is identified by the level of standardization of the software tools utilized in the software projects
	Intensity of the interaction	a) Duration of the project: number of fays, weeks or months. b) Quantity of information interchanges (high, medium, low)
	Formal and informal interaction	a) Meeting of work documented and systematized. b) Meeting of work neither documented nor systematized.
Absorptive capacity	Prior knowledge	a) Employee's basic abilities b) To hire new employees with formal education
	Information and knowledge flows into the firm	a) Systems for processing infomation and knowledge b) Internal forums for discussion c) Team works
	Learning activities	a) Learning by reutilization b) Learning by training c) Learning by *multitask* activities into the firm d) Learning by R&D

Knowledge	General information	a) Specialized magazines, internet b) Seminars, consulting
	Specific information	a) Internal and external training b) Users
	General knowledge	a) Employees hired in the last year with formal education but without specialized training
	Specific knowledge	a) Employee's years of experiences b) Internal and external training c) Users

Source: Own elaboration, based on review of literature.

III. *Characteristics about customized software industry in Mexico*

The Mexican Information and Communication Technologies (ICT) industry is on a stage of development and growth. It represents 1.4% of the Gross Domestic Product (GDP)[7], while the Mexican software industry contributes with 0.1% in the GDP[8] (SE, 2005). Despite the deep technological gap compared with U.S.A or European countries, in Latin-American Mexico ranks second in all sectors of ICT, after Brazil (Mochi, 2006). During the period from 1992 to 2003 the manufactured software industry participated with 7.7% annual average in the total production of ICT, the IT services industry participated with 22%, Hardware industry with 40.7%, and others with 29.6%. If well it is not possible to know the real data about software industry,[9] this industry has an atomistic structure: 87% are micro and small-sized firms,[10] and most of them have an organizational structure of work based on a *multitask scheme*. Moreover, according Mochi (2006), almost 80% of the firms are producing or selling package software, and around 20% of the firms designs and develops customized software.

Table 2 shows us different segments of the Mexican software industry. The own production and consumption represents the major percentage of the total industry, 62.6%; while the packaged software represents 29.4%; and the customized software just represents 8.0%. If government agencies and large firms hire independent software firms could increase the demand of customized software. This will be possible if software firms have technological capabilities to offer solutions to specific problems from the government agencies and manufacture firms, and if these agents decide to leave out producing it themselves and hire it to independent software firms.

The domestic demand of customized software is concentrated in the retail services, financial, electronic and automotive industries. The types of users are government agencies and medium and large-sized firms.

[7] That percentage represents in average 4.3% in the countries of the Europe Union and 5.5% in U.S.A. (SE, 2005).
[8] That percentage is 6 times lower than the world average and 9 times lower than the U.S.A (SE, 2005).
[9] Some scholars and policy makers suggest that there are 1500 firms more o less.
[10] Based on a survey done by AMITI (2001) and by González (2006).

Table 2.
Participation by software segment, and sectors of demand, 2005

Type of segment	Production/ (md)	Participation rate	Sectors of demand (in order of importance)
Package software	817	29.4%	Services, Government, Financial, Retail Services, and Manufacture.
Customized Software	221	8.0%	Services (financial, insurance, education, transportation, health, culture), Government, Industry (manufacture y mining, etc.), and Retail Services.
Own production and consumption	1,738	62.6%	Government and Manufacture.
Total	**2,776**	**100%**	-

md: millions of dollars.
Source: Own elaboration, based on Mochi (2006).

IV. Principal Findings

Table 3 summarizes some characteristic of the firms. Five of them are micro and small-sized firms and were created with personal financial resources. Except Goya, which is a medium-sized firm with an organizational structure of work based on formal and functional areas. The firms utilize different software technologies to design and develop software programs, and the regular activity is the design and development of customized software. Their principal market niches are services, manufacture, government, and education.

Table 3.
Differences and similarities among the case studies

Characteristics		Open-source software firms	Proprietary-software firms	Level of difference or similarity
Technology	Operating systems	GNOME, LINUX	WINDOWS	High
	Tools	PHP, JAVA	JAVA, ORACLE	Medium
Type of s oftware developed		Customized software	Customized/package software	Low
Certification		CMM3 (1 firm)	CMM3 (3 firms)	High
Firm's size		Micro	Micro and medium	Medium
Origin from capital		Personal savings	Personal savings	There is not
Market niche		Services, manufacture, government	Services, manufacture, education	Low

Source: Own elaboration, based on interviews.

The case studies have created different type of interfaces. Next table show us the six firms and the type of interface related to each one. Constable, for instance, is related to simple interface, Velasquez and Degas to semi-complex interface. Manet, Renoir, and Goya are related to complex interface, although the last three firms give us information to know and study in depth the characteristic about simple interfaces.

Table 4.
Type of interface related to each firm

Firm / Interface		Simple	Semi-complex	Complex
OSSW*	**PSW****			
Constable		v		
Velasquez			v	
Degas			v	
Manet		v		v
Renoir		v		v
Goya		v		v

*__OSSW__: open-source software. **__PSW__: proprietary-software.
Source: Own elaboration, based on interviews.

Simple, semi-complex, and complex interfaces

As opposite to the bodies of literature, the evidence about Mexican software firms has showed us that they have created three types of interface: simple, semi-complex, and complex; and not two as the literature suggests us, simple and complex. The six firms show us how and why they create different interfaces with other social actors. Table 5 summarizes the principal characteristics of each interface. All interfaces are designed starting different categories: a) actors involved in the project (users, universities, government agencies, and so on), b) formality, informality, intensity, and complexity of the interaction, and c) stability or complexity of the technology.

Table 5.
Characteristics of the interfaces

Category / Interface	Simple	Semi-complex	Complex
Type of social actor involved in the interaction	Passive users, 'integrative' firm	Pro-active users	Active and 'aware' users, universities, developer communities of open-source
Type and complexity of the interaction	Installing software that already exists in the market, micro and small modification, selling-purchasing contract	Improving or upgrading software applications; design and development of new applications; testing software; training	Analysis, design and development of new applications; testing software; training and creation of specialized human resources
Stability of the technology	High, SWT* widely spread into the software industry	Medium, SWT* with low level of stability, but not much spread into the software industry	Medium-low, SWT* with low level of stability, and not much spread into the software industry
Intensity of the interaction	Low, projects of short-time (1-2 months)	High, projects of long time (5-16 months)	High, projects of long time (8-24 months)
Formal and informal interaction	Formal, based on selling-purchasing contract	Formal at the beginning of the project, informal in the last stages of the project	Formal at the beginning of the project, informal in the last stages of the project

*__SWT__: software technology.
Source: Own elaboration, based on interviews.

Through each interface the software firms can identify useful I&K in order to design and develop software programs. Once they have identified I&K they need to internalize them in order to increase their absorptive capacity.

Simple interface is shaped and determined by the information that exists in the codified environment. The type of project is about to develop software programs similar to other that exists in the market. The projects imply activities such as remade and installing software, as well as maintenance of systems that have been installed in the user firm. Some times the specification to do that not implies a high user-producer interaction. The reason is because of producer need relatively simples and great mounts of information about requirements, which it is possible to find in the codified environment. The majority of the times the interaction is just for doing a formal selling-purchasing contract. When the user is part of a maturity industry there are great amounts of information and codified knowledge about the organizational and productive processes. Producers can identity the necessary information to develop software applications by codified means such as books, journals, seminars, and so on. So, there are little information and knowledge that user and producer interchange. For this reason, the intensity of the interaction is low, few hours are enough to identify the information to cover particular requirements (in some case from 10 to 20 hours in total are enough, or well 3 or 5 days). Four firms have done at least one project with these characteristics.

Semi-complex interface is shaped and determined by the information and knowledge that exist in both the codified environments and active users. In this case the producer can find by codified means the information about the productive and organizational process to develop software program that the users need. The users are also important means to obtain the information because of they have specific information about their requirements and necessities that the producer can not find easily by codified means. In this type of interface the project implies to design, develop, improve or upgrade software applications. In the stages of analysis and design the interaction is high and the user is active.

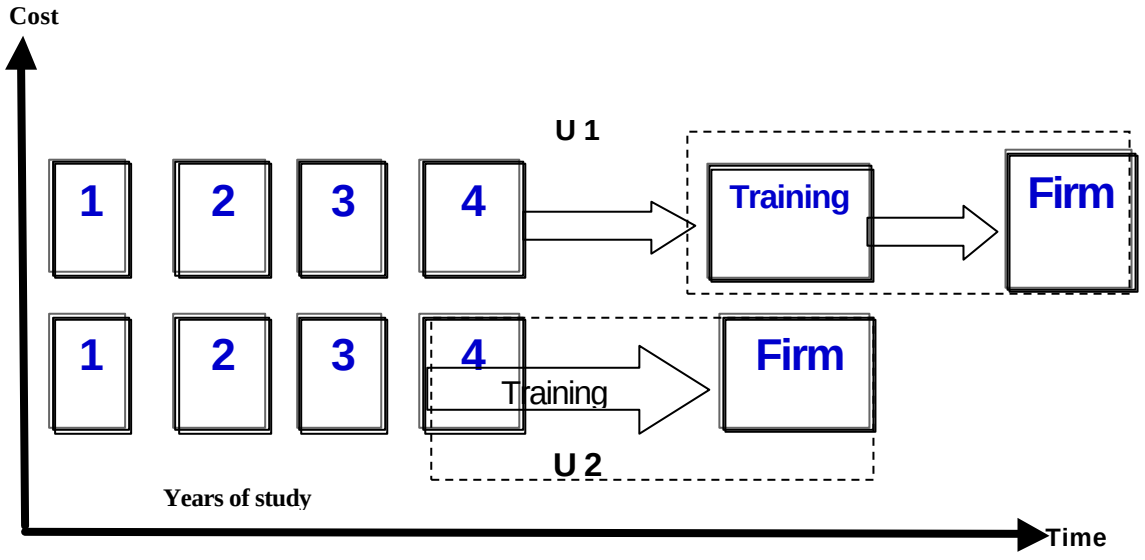
For instance, we will present the case of Degas firm. This firm is a small-sized firm that develops software to leather-tanning sector. Degas' owners had worked in a leather-tanning firm before they created the firms, so, they know the productive ad organizational process from the users. This firm finds information and codified knowledge in the codified environment, but specific information and knowledge is incorporated in the people that worked in user firms. So, the user-producer interaction is important because of there is a tacit knowledge that the producer need in order to develop software programs. In this case, there is a high level of interaction. 'A good design of the project is calibrated by the user', and the software program will be efficient if the user-producer interaction is deep.

The user will need to get a proper training to use a software program, which means the producer trains to users. Few users have used software program in their productive areas, but through the system designed by Degas the user has improved their productivity, reduce costs, and increase the production of leather. The project lasted between 12 months. At the beginning of the project the interaction is formal, but at the end the interaction is informal because of the people create an 'environment of trust'.

Complex interface is shaped and determined by the information and knowledge that users have developed and accumulated. In this case users, universities, and developer communities have taken a pro-active role in the interface creation process. These actors have specific information and knowledge that the producer can not find in the market. The project implies new software programs, but also the creation of human resources with specific abilities through training or linkages between firm and university. For instance, it is important the linkage between Goya (the firm) and Univer (the university). The aim was to create human resources with specific abilities on software technologies.

Some small and medium private universities have begun to 'produce' core-knowledge but, in general terms, they do not know the sector's specificity because these universities do not have interaction with the software firms. In the figure 1, we can see the outline for two kinds of universities (university type 1 -U1- and university type 2 -U2 (in our case Univer)-). The U1 generates students with general knowledge and whether the student wants to work in the software industry he will need training. The firm that would employ him will offer the training. On the other hand, the U2 offers students with general knowledge, but with added value. The added value is the training in specific areas of ICT or computer sciences. If the student wants to work in the software industry he won't need training because he has it. The firm will save time and costs to enable him.

Figure 1 Two different models to generate human capital for the software industry



Source: Own elaboration, based on interviews.

Univer and Goya have created educational programs, in which the student obtains general knowledge over a long 3 years of study, and in the last year they may specialize in some kind of specific knowledge that Goya and the software industry needs. This type of project implied 2 years to implement educational programs and four to obtain the firsts students.

The linkage between Goya and Univer was high. At the beginning of the project the interaction was formal, but at the end the interaction was informal. One of the results of this project was that Goya could obtain specific knowledge to design and develop software programs in the short time.

Absorptive capacity starting external interfaces

The firms can internalize I&K generated in the environment. The mechanisms to do that are starting prior knowledge, I&K flows (internal discussion forums), and other learning activities such as training. This is summarized in the table 6.

Table 6.
Principal mechanisms to increase the firm's absorptive capacity

Firms	Prior knowledge		I&K flows (internal flows)		Learning activities			
	Basic abilities	New employees hired	Processing of observable knowledge	Transfer of I&K into the firm	Reutilization	R&D	Training	Multitask activities
Constable	v	v	v		v		v	v
Velasquez	v		v				v	v
Degas	v	v					v	v
Manet	v			v	v			v
Renoir	v	v	v	v		v	v	v
Goya	v	v	v	v			v	

I&K: Information and knowledge
Source: Own elaboration, based on interviews.

a) **Prior knowledge**: If well all the firms have basic abilities related to their technological market niche, only Constable, Degas, Renoir and Goya have hired new employees in order to increase their knowledge base.
b) **I&K flows** (internal flows): Few firms have systems for processing observable I&K. Some firms have done it because of they are involved in the certification process (CMMi level 3), but Degas and Manet do not have that systems because of they are not in that certification process. The transfer of knowledge into the areas is an important activity, particularly the 'discussion forums'. This activity allows to the employees to share experiences about problem solutions obtained into the different projects, at the same time, this activity allows to the firm to internalize I&K generated in the environment, expressly that of major specificity.
c) **Learning activities**: The evidence shows us that only Constable and Manet utilize frequently the 'reutilization of modules' of software applications and tools as learning activity. Only Renoir has R&D activities. But, all the firms considered the training like the core learning activity at organizational level (except Manet). The multitask activity allows to the employees to learn at individual level, but it reduce the learning at organizational level.
d) The knowledge flows (particularly internal discussion forums) and learning activities (specially training) are activities that contribute to increase the firm's absorptive capacity.

Each firm is related to one type of interface, and each interface has an effect in the firm's absorptive capacity. Next table show us this causal effect.

Table 7.
Interface and the level of absorptive capacity

Firms	Type of interface	Internalization (absorption) of I&K	Level of absorptive capacity
Constable	Simple	Of general purpose	Low
Velasquez	Semi-complex	Of general and specific purpose	Moderate
Degas	Semi-complex	Of general and specific purpose	Moderate
Manet	Complex	Specific (and of general purpose*)	Significant
Renoir	Complex	Specific (and of general purpose*)	Significant
Goya	Complex	Specific (and of general purpose*)	Significant

* In well the firm identifies specific I&K through the social actors (particularly through the users) and internalized them, it can internalize I&K of general purpose, although these are of minor relevance to design and develop new applications.
I&K: Information and knowledge
Source: Own elaboration, based on tables 4 and 6.

Four software firms have increased their absorptive capacity in a limited way. They have abilities to absorb general information and knowledge, it is to say, information and knowledge about software programs and software tools that have been standardized and that become 'common sense' in the industry, but they have not showed the ability to absorb specific information and knowledge to design and develop new products, process or services. In this sense, simple interface is a mechanism to absorb general (but not specific) information and knowledge.

The evidence has show that firm's projects are particularly about remade software, as well as maintenance of systems that have been installed in the user firm. In our study, four Mexican software firms do not design and develop new software programs but they remade software that already exists in the market. So, the firms can identify general information in a codified environment because they have 'prior knowledge' to do that, it is to say, they have hired engineers with knowledge about general processes.

In this case, the firms do not need systems for transfer and processing knowledge because the type of project they made is relatively simple. Few times is necessary to train engineers, in fact, the 'rotational roles' into the firm is high but the information and knowledge the engineers interchange is about general technical and organizational processes. In this respect, in our study, the four software firms can increase their absorptive capacity, but it refers to general information and knowledge.

There are other firms that have increased their absorptive capacity of specific information and knowledge. In the semi-complex interface case, we showed an example in which the producer has prior related and specific knowledge, it is to say, the engineers had worked in a leather-tanning firm before they created the Degas, so they know the productive ad organizational process from the users.

This firm has systematic processes to transfer and processing knowledge, which permits to register the solutions at technical problems that the engineers find a long the projects. It is important to mention that Degas makes just one type of software, programs to leather-tanning sector, however, each user has different requirements, and therefore each project is different. One of the best mechanisms to internalize specific information and knowledge is through 'rotational roles' among different stages of the project, which is usual among the micro and small-sized firms. This mechanism assures the individual internalization but reduces firm's specialization and

organizational internalization. And just the firms (like Degas) that develop other mechanism such as 'internal training', 'internal forums', and that support their activities on 'aware users', 'developer communities', or 'universities', will increase their absorptive capacity.

Finally, there are other firms like Goya that created a complex interface. In this case, this firm has obtained specific information and knowledge through hiring new engineers; the specificity of the engineers is that they have been trained into the university (Univer) in specific software technologies that Goya and other firms use. In this case, the 'rotational roles' into the firm is one of the best mechanism to internalize information and knowledge from the users. The reason is because of Goya has implemented: i) forms to register and process the solutions to particular problems, ii) training programs into the firm, iii) internal forums in order to share the knowledge about specific solutions to particular problems.

Knowledge creation

The creation of new knowledge expressed into new software programs, processes, and services, has levels of complexity and dynamism. We consider that new knowledge depend on the kind of I&K that software firms can identify and, at the same time, it depends on the mechanism to internalize them in order to design and develop software programs. Next table summarizes the output from the type of interface and the type of I&K that have been internalized.

Table 8
Creation of I&K starting different types of projects.

Interface	*Important inputs identified and internalized*	*Project*	*Output*
Simple interface	-I&K of general purpose	-Reply, adaptation and minor improvements to applications that already exist in the market - Selling-purchasing contract	-Abundant and repetitive information, and knowledge of general purpose
Semi-complex interface	-I&K of general and specific purpose	-Upgrading and updating applications already installed in the user firms	-General and codified knowledge -Specific information
Complex interface	-I&K of specific purpose	-Design and development of new products, processes and services.	-Specific and tacit knowledge -Specific information -Specialized human resources

I&K: Information and knowledge,
Source: Own elaboration.

It is necessary to consider that the firms that remade, installing, or maintenance software, can identify in an easy way general I&K. The firms do not need the user to find it, because of the codified environment gives them general I&K. In this case, the firms that are able to internalize them will increase their absorptive capacity in a low level, which means they can not create new software programs because they are unable to identify specific I&K.

We suggest that the firms that have designed and developed programs software are able to identify specific I&K because they interact in a high level with active and 'aware' users. In this case the codified environment is not enough; the firms need users to identify specific I&K. In this case, to create new software programs depends on the ability to internalize specific I&K.

So, in both simple interfaces predominates the creation of general I&K. But, in semi-complex and complex interfaces are crucial the knowledge flows and the generation of new software programs.

The general knowledge is created starting different specialties such as information technology, computing systems, computing sciences, management systems, information systems, applied mathematics and computation, and so on. But the sector needs specific knowledge in the following technologies: system infrastructures (middleware –legacy systems), multimedia 2D and 3D, Internet platforms, Linux-base software, software testing, inside and outside networks, and so on. In this sense, the creation of external and complex interface seems to have a better possibility to create new products, processes and services, and not just information. But this depends on the ability to internalize the information and knowledge that exist in the environment but also that generated in the interface.

V. Conclusions and discussion

The great dynamism of the software industry creates uncertainty among software firms because it implies creation of great amounts of I&K, which the firms need to identify and absorb in order to design and develop software programs. Those I+K are fragmented because of each actor has an important part of them, and they take coherence when are articulated through the interface.

We have show that Mexican software firms have created different interfaces, which need to be modified constantly in order to solve specific problems from users. We found that in Mexico there are software firms on simple interfaces that could exist for a long time, at the same time it implies that producers and users are passive in a dynamic market. This implies the principle of commodity abstraction define by Andersen (1991). In this situation the producer, for instance, could improve the sales, installing package software in the user firm, but this pattern could reduce the capacity to create new software programs.

We also found that other firms have created semi-complex and complex interfaces. One type of interface will have a different effect on the level of firm's absorptive capacity. The creation of these types of interface allows to the firms identify specific I&K, which could be used to design and develop new software programs, and not just remade or installing software programs, but it depends on the ability to internalize specific I&K that exist in the environment but also that generated in the interface.

The software technologies and user's requirements changes in a very fast way and just some Mexican software firms are able to modify their behavior as the software industry requires. The process to increase the absorptive capacity is crucial to reach that. Two of the most important mechanisms to increase it are the 'internal discussion forums' and 'internal and external training'. One of the problems for the micro and small-sized firms is their organizational structure of work, which is based on a *multitask scheme*. This scheme reduces the firm's capacity to create internal knowledge flows and, if well it assures the individual internalization, it reduces firm's specialization and organizational internalization.

Finally, the evidence shows us that software industry has an important impact on other industries different of the ICT, for instance, on leather-tanning industry. The interaction between both industries allows to the software firms to create new applications and *revive* traditional firms. This shows us that Mexican software firms have the capacity to explore new market niches: high tech markets but also traditional markets. This transversal aspect is extremely important to develop the customized software industry. New software programs, processes, and services could be created if the firms create interfaces in order to identify suitable I&K, and if the firms have suitable mechanism to internalize specific I&K that exist in the environment but also that generated in the external interfaces (semi-complex and complex).

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